VALUE ENGINEERING IN THE TQM ENVIRONMENT

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ABSTRACT

This paper gives an overview of what value practitioners need to know about total quality management (TQM) and its allied disciplines of concurrent engineering (CE), design of experiments, (DOF) and quality function deployment (QFD). References are given to guide the integration of the VE Job Plan in the TQM environment. The commonality among TQM, its allied tasks, and VE is shown.

INTRODUCTION

Key elements of success in high technology are technical supremacy, quality, and competitive business posture. Industries and nations around the world have come to view TQM as the imperative for achieving these elements of success in the global marketplace. Only organizations with the proficiency to perform in the TQM environment will prosper in this increasingly competitive arena, and that value practitioners should heed the same admonition.

It is important, however, that value practitioners never forget that VE will remain at the forefront of skills dedicated to achieving affordable quality, provided VE practitioners capitalize on what these other skills have to offer. TQM and its allied disciplines have vital roles toplay in keeping programs on course within requirements, schedule, and cost, but only VE can ensure that essential functions are provided at lowest possible cost.

VE JOB PLAN

The challenge is to ensure that the elements of the job plan and the ensuing work are in concert with the task requirements of TQM and its allied disciplines. The following guidance is offered.

Project Initiation.
This is where project planning, definition, and team building occurs. VE is team-oriented and it is critical that a cohesive, multidisciplinary, team be assembled. People and supplier problems are the obstacle to progress and it is important that motivational schema be in place by the start of the project. This element of the project should consider task requirements for TQM, CE, Taguchi method of design of experiments, and QFD given in the references.

Information Phase.
This phase is the foundation for the VE project. The focus is on the basic VE question: "What must it do?". Answers are expressed in concise verb-noun phrases (Supply-space, Illuminate-area, Protect-inventory). Avoid the question of "How to do it?" that constrains creativity. Information needs should include the task requirements for TQM,CE, Taguchi methodof DOF, and QFD given in the references.

Speculation Phase.
Judgment is suspended in this phase as teams use creative-thinking to identify all possible alternative solutions. Beginning with basic functions, teams evolve alternatives without supporting and unnecessary functions. Basic functions make "it" work. Supporting functions enhance "it." Speculation should include the task requirements for TQM, CE, Taguchi method of DOE, and QFD given in the references.

Analysis Phase.
This phase determines the means of implementation and the cost of alternative solutions. The focus is now on the questions: "What does it cost?" and "What is its functional worth?" Alternative solutions are ranked by functional worth. Functional worth is the lowest cost means to perform the basic function. Analysis should include the task requirements for TQM, CE, Taguchi method of DOE and QFD given in the references

Development Phase.
This phase structures acceptable alternative solutions in suitable format for presentation to decision-level management. The team evolves the recommended solution on the basis of the key issues: development time and cost; life-cycle cost; and return-on-investment. Development should proceed in the framework of the task requirements for TQM, CE, Taguchi method of DOE, and QFD given in the references.

Presentation Phase.
This phase puts the myriad of information into a concise but credible presentation to management. The key issues are how recommendations relate to organizational goals and the risk in implementing the recommendations. The adequacy, realism and credibility of the supporting documentation determine the success of the project. The presentation should emphasize the satisfaction of the task requirements for TQM, CE, Taguchi method of DOE and QFD given in the references.

Implementation Phase.
This phase develops the action plans to bring the full benefit of the alternative solution, approved by management, into the organization. Included in the phase are periodic checks on the progress in implementing the approved solution. Again, implementation should accommodate the task requirements for TQM, CE, Taguchi methodof DOE, and QFD given in the references.

TOTAL QUALITY MANAGEMENT

Much of TQM is accomplished within the context of Dr. W. Edwards Deming's pioneering effort that lead to his enunciation of principles given in Table 1. In addition, TQM ideology embraces the integration of the forward-thinking notions of CE, the Taguchi method of DOE, and QFD. Table 1 should be considered a checklist for integrating the VE job plan in the TQM environment.

TQM connotes an organizational strategy to make quality a driving consideration in each phase of product life cycles. The objective of TQM is to change the long-standing industrial culture of acceptable quality to one with the constancy of purpose for continuous improvement of quality and productivity on a company-wide basis. TQM is thus defined as a total organizational approach to continuous improvement of quality and productivity directed toward cross-functional goals of increased customer and user satisfaction..

The tasks comprising TQM and their objectives are listed in Table 2. The essence of TQM is embodied in Task 4 that states: " Implement TQM performance improvement projects using offline quality control and online quality control methodologies." The significance of offline quality control and online quality control is brought out below in the discussion of the Taguchi method.

Table 1 **Fourteen Management Principles of Dr. Deming ***

1. Create constancy of purpose for improvement of product and service.
2. Adopt the new philosophy.
3. Cease dependence on inspection to achieve quality.
4. End the practice of awarding business on basis of price tag alone.
5. Improve the process of planning, production, and service.
6. Institute modern methods of training on the job.
7. Institute modern methods of supervision.
8. Drive out fear.
9. Break down barriers between staff areas.
10 Eliminate slogans, exhortations, and targets for the work force.
11 Eliminate numerical quotas for the work force and numerical goals for management.
12 Remove barriers that rob people of pride of workmanship.
13 Institute a program of education and self improvement.
14 Put everybody in the company to work to accomplish the transformation.

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* Reprinted from Defense System Management College, *Defense Manufacturing Management Guide for Program Managers*, 1989. By courtesy of the Defense System management College, Fort Belvoir, Virginia

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Table 2 **TQM Tasks**

1. TQM Planning. Provide preliminary evaluation of the organizations *TQM* performances, identifies and ranks areas for improvement, and evolves schedule for implementing TQM improvement projects.

2. Establish TQM Environment. Establish management and cultural environment in terms of vision and long-term commitment, people empowerment, disciplined methodology, support systems, and training

3. Define TQM Mission. Define TQM mission for each component of the organization, sets TQM performance improvement goals, and establishes TQM improvement projects and action plans.

4. TQM Implementation. Implement TQM performance improvement projects using offline quality control and online quality control methodologies.

5. TQM Evaluation. Evaluate TQM performance improvement in terms of cycle time, lower cost, and product innovations, and recycles the process as required.

Table 3 serves as a benchmarking matrix to assess status of TQM implementation from the perspective of customers and users. Implementation is ranked on an inverse scale of 5 to 1; with Category 1 being the traditional, costly,approach to quality control.

Table 4 serves the same purpose from the perspective of suppliers. Drawing a parallel with traffic signals, the table is called the Green-Yellow-Red Audit Board to connote acceptable (green), marginal (yellow), and unacceptable (red) readiness.

CONCURRENT ENGINEERING

CE is defined as a systematic approach to the integrated, concurrent design of products and their related process, including manufacturing, and support. The approach is intended to cause the developers, from the onset, to consider all elements of the product life cycle from conception through disposal, including quality, cost, schedule, and user requirements.

Alternatively, CE can be defined as the simultaneous and integrated engineering of all design, manufacturing, and support aspects of a product from concept through availability. In this regard, CE can be considered an embodiment of the way system engineering is supposed to work.

CE is a teaming concept; bringing together all the people who normally would be involved sequentially over the life cycle of programs to address how products will be produced, tested, used, and supported. The considerable up-front investment requires considerable management conviction about the value of CE.

The tasks comprising CE, and their objectives, are listed in Table 5. The close parallel with system engineering tasks and objectives, as they should be performed.

Note also the close parallel with the VE job plan. Planning, requirements analysis, functional analysis and allocation, system synthesis, and requirements and resources balance tasks in CE are essentially the same as the first-six elements of the VE job plan: project initiation; speculation phase; information phase;, analysis phase; development phase; and presentation phase. The work in the last element of the job plan, implementation phase, is essentially the same as the work that is done following the tasks comprising CE and system engineering.

Table 5 **CE Tasks ***

1. Planning.
Spell out the scope and depth of the tasks comprising CE process, inputs to the process, and the outputs of the process.

2. Requirements Analysis.
Define, derive, and refine performance requirements (i.e., what item must do and how well).

3. Functional Analysis and Allocation. Derive and refine lower level functional requirements (i.e., what lower-level items must do and how well).

4. System Synthesis.
Define and refine system element alternatives and selects preferred system elements solution

5. Requirements and Resources Balance. Balance requirements and resources available to meet requirements with trade studies, effectiveness analysis, and risk assessment, and track progress of the CE process.

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* Adapted from Dr. Jerome G. Lake, "Concurrent Engineering: A New Initiative", *PROGRAM MANAGER*, September- October 1991, by courtesy of the Defense System Management College, Fort Belvoir, Virginia.

TAGUCHI METHOD OF DOE

The objectives of DOE in the product and process domain are to:

1) Identify the important variables whether they be product or process parameters, materials or components from suppliers, environmental or measuring equipment factors;

2) separate these variables into one to four important variables;

3) reduce the variation on the important variables through close tolerancing; and

4) open up tolerances on the unimportant variables to reduce cost substantially.

Classical DOE was pioneered in the early 1920's by Dr. R. A. Fisher, who devised techniques for running agricultural experiments in the imperfectly controlled conditions of the outside world rather than in a greenhouse. His methodsproduced good results in medicine, education, and biology and were quickly adopted in these disciplines. Unfortunately, understanding and support in mainstream industry in the western world has been limited. Dr. Fisher's approach was based on factorial design. The Japanese, in particular Dr. Genichi Taguchi, have been successful in using fractional factorial design, along with other orthogonal arrays, to improve products early in the manufacturing process.

The most important distinction between Taguchi's approach and the classical approach is the manner in which product and process variability are perceived. In the former, the user is assumed to be completely satisfied as long as the product falls anywhere within specification limits. Taguchi, on the other hand, postulates that loss occurs increasingly as products deviate from target values.

To minimize the loss, products should be produced with minimal variations in their functional characteristics. The factors that effect functional characteristics of products are either controllable or uncontrollable; the latter being called noise. Noise factors are either difficult, impossible, or expensive to control. In essence, the ability to recognize variations which are within and beyond control provides the ability to gain full control by design compensation. Savings are substantial.

QUALITY FUNCTION DEPLOYMENT

QFD is a management concept that provides the means for translating user requirements into the appropriate technical requirements for each stage of product development. The concept is further broken down into product quality deployment and deployment of the quality function.

Product quality deployment constitutes the activities needed to translate the voice of the user into counterpart characteristics. The voice of the user denotes the user's requirements expressed in the user's own terms. Counterpart characteristics are expressions of the user's requirements in technical language that specifies user-required quality. Counterpart characteristics are critical final product control characteristics.

QFD constitutes the activities needed to assure that user-required quality is achieved by theassignment of specific quality responsibility to specific departments. The term quality function does not refer to the Quality Department, but rather to any activity needed to assure that quality is achieve irrespective of which department performs the activity.

QFD tasks and objectives are listed in Table 5. The matrix used to translate the voice of the user into final product control characteristics is referred to as a house of quality by John R. Hauser and Don Clausing in the May-June 1988 issue of the *Harvard Business Review*.

Table 6 **Tasks and Objectives in QFD** *

Overall User Requirement Planning Matrix. Translate the voice of the user into counterpart control characteristics. Provide the way of turning general user requirements, drawn from market evaluations, comparison with competition, and marketing plans, into final product control characteristics.

Final Product Characteristic Deployment Matrix. Translate the output of the planning matrix (i.e., the final critical component matrix) into critical component characteristics. Move one step further back in the design and assembly process.

Process Plan and Quality Control Charts. Identify critical product and process parameters, as well as control and check points for those parameters.

Operating Instructions.
Identify operations to be performed by plant personnel to assure that important parameters are achieved.

* Reprinted from Defense System Management College, *Defense Manufacturing Management Guide for Program Managers*, 1989. By courtesy of the Defense System Management College, Fort Belvoir, Virginia.

The long-term benefits of QFD to organizations that are willing to undertake the upfront expense are:

1. Product objectives based on customer requirements are not misinterpreted at subsequent stages of development and production.

2. Particular marketing strategies or sales points do not become lost or blurred during the translation process from marketing throughplanning, development, production, and delivery.

3. Important production control points are not overlooked with everything necessary to achieve the desired outcome being in-place and understood.

3. Tremendous efficiency is achieved from reduced need for changes from misinterpration of program objectives, marketing strategy, and critical control points.

COMMONALITY AMONG CE, QFD, TQM, AND VE

Table 7 is a commonality matrix for CE, QFD, TQM and VE. Note that there is a check in each row of each column of the matrix indicating the total commonality among VE and the disciplines of interest. The interaction of VE with TQM and its allied disciplines is synergistic with respect to improved functionality, quality, affordability, and profitability. The synergistic product has earned the acronym of QFAP.

SUMMARY

The paper introduced what VE practitioners need to know about TQM and its allied disciplines These are: CE; QFD; and DOE. The latter has been developed into a highly sophisticated technique for increasing quality by reducing variability and is called the Taguchi Method in honor of its inventor, Dr. Genichi Taguchi.

It was shown that there is total functional commonality among these disciplines and VE. References to pertinent texts were given.

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Table 3 Benchmark Matrix to Assess Status of *TQM* Implementation

TQM Category (Standing ⟶ Desired Direction)	Top Management Commitment	Obsession with Excellence	Organization is Customer Driven	Customer Satisfaction	Training	Employee Involvement	Use of Incentives	Use of Tools
5	Continuous improvement is a natural behavior even for routine tasks	Constant, relative improvement in cost and quality	Customer satisfaction not profit, is primary goal	Customer intends to maintain long-term business relationship	Statistics is a common language among all employees	People empowerment: self-directing work groups	Gain sharing (cross-functional teams)	Use of design of experiments and quality function deployment
4	Focus is on improving the system	Use of cross-functional improvement teams	Customer feedback used in decision-making	"Things done right the first time"	Top management understands and applies TQM philosophy	Manager defines limits; asks group to make decision	More team than individual incentives and rewards	Design and other departments use SPC techniques
3	Adequate money and time allocated to continuous improvement	TQM support system set up and in use	Tools used to include wants and needs in design	Positive customer feedback; complaints used to approve	On-going training programs	Manager presents problem, gets suggestions, makes decision	Quality-related employee selections and promotion criteria	SPC used for variation reduction
2	Balance of long-term goals with short-term objectives	Executive steering committee set up	Customer needs and wants are known	Customer rating of company is known	Training plan developed	Manger presents ideas and invites questions, makes decision	Effective employee suggestion program used	SPC used by manufacturing
1	Traditional approach to quality control – Inspection is primary tool (control of defects, not prevention) – Better quality – higher cost – Quality control only found in manufacturing departments MBO used for all departments							

Reprinted from DoDG 5000.51.G, *Total Quality Management: A Guide for Implementation*, 1990.
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Table 4 Green-Yellow-Red Quality Audit Board

Missile Systems		Product Quality Status Audit Readiness Rating												
Measurement Criteria		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Area Team Members
1	Effective corrective action													
2	Safety													
3	Nonconforming hardware													
4	Documentation/ configuration management													
5	Procedures													
6	Shelf life material													
7	Tool calibration													
8	Facilities/ housekeeping													
9	Property Management													Remarks:
10	Handling and packaging													● Unsatisfactory red
11	Training and certification													● Marginal yellow
12	Discipline/ management responsiveness													◎ Acceptable green

Reprinted from Martin Marietta Engineering Practices Manual, *Design to Cost*, 1992.
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Table 7 Commonality Among Concurrent Engineering, Quality Function Deployment, Total Quality Management, and Value Engineering

	CE	*QFD*	*TQM*	*VE*
Multidisciplinary Teams	✓	✓	✓	✓
Skills and Teams Training	✓	✓	✓	✓
Systematic Process for Teams	✓	✓	✓	✓
Functional Analysis	✓	✓	✓	✓
Encourages Creativity	✓	✓	✓	✓
Challenges Requirements	✓	✓	✓	✓
Reduces Cost	✓	✓	✓	✓
Improves Producibility	✓	✓	✓	✓
Design Trades for Cost	✓	✓	✓	✓
Uses CAEDM	✓	✓	✓	✓
Optimizes Designs	✓	✓	✓	✓
Uses Design of Experiments	✓	✓	✓	✓
Collocates Teams	✓	✓	✓	✓

CAEDM: Computer-Aided Engineering, Design, and Manufacturing
CE: Concurrent Engineering
QFD: Quality Function Deployment:
TQM: Total Quality Management
VE: Value Engineering